I. C. 6889 JUNE 1936

DEPARTMENT OF THE INTERIOR

UNITED STATES BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

MINING AND GRINDING METHODS AND COSTS AT THE CAMP BROTHERS COMPANY SHALE PIT, MOGADORE, OHIO

BY

E. J. LINTNER

AFTER THIS REPORT HAS SERVED YOUR PURPOSE AND IF YOU HAVE NO FURTHER NEED FOR IT, PLEASE RETURN IT TO THE BUREAU OF MINES, USING THE OFFICIAL MAILING LABEL ON THE INSIDE OF THE BACK COVER.

I.C. 6889
June 1936

INFORMATION CIRCULAR

DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

MINING AND GRINDING METHODS AND COSTS AT THE CAMP BROTHERS COMPANY SHALE PIT, MOGADORE, OHIO[1]

By E. J. Lintner[2]

INTRODUCTION

This paper is one of a series being prepared by the United States Bureau of Mines describing clay mining and crushing methods and costs at various operations throughout the United States. These papers are designed to disseminate technical information regarding methods used. The cost tabulations represent local operating expenditures only and not total production costs. It is recognized that publication of total production costs might perhaps, in many instances, cause embarrassment to the individual operator as well as to the industry as a whole. On the other hand, operating costs are essential to the technical discussion and study of the methods employed. The attention of the reader is specifically called to this distinction in order that no misunderstanding of the scope of the cost tabulation shall ensue.

The following report deals specifically with the methods employed by the Camp Brothers Company, Mogadore, Summit County, Ohio.

The author wishes to acknowledge the assistance of the following persons, who gave freely of their time: H. H. Camp, president; C. C. Baird, treasurer and general manager; N. A. Myers, office manager; and George Stuber, plant superintendent.

Historical

The first clay deposit in Summit County was found in 1828 by a Mr. Fisk. He discovered a bed of potters' clay in the field of a neighbor near the village of Mogadore. A partnership was formed with a Mr. Smith, and under the firm name of Fisk & Smith they purchased this field and established a pottery. They began to manufacture the first ceramic products in this section. This plant was operated until 1840, when it was destroyed by fire. In this same year, Mills Reed started a small mill to manufacture stoneware. Shortly after, Josiah Lee obtained this plant and, with various partners, conducted a stoneware business for about 30 years.

---

[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U.S. Bureau of Mines Information Circular 6889."

[2] Associate mining engineer, U.S. Bureau of Mines.

A little later, Charles and John Martin bought an old tannery and turned it into the first paving-brick plant in this locality. A large number of these brick were shipped to the growing city of Cleveland, where they were used on the streets in place of cobblestones.

Other new companies were formed from time to time. These later changed hands or discontinued business entirely. However, Mogadore continued to "manufacture hundreds of thousands of gallons of stoneware and millions of smoking pipes annually."3/

The last company to start operations in this field was The Camp Brothers Company. This company was organized in 1919 with H. H. Camp as President. The plant was built in 1920, and production of brick and building tile was begun early in 1921. Today, this company is one of the leaders in the ceramic industry in Summit County.

The plant is within the corporate limits of the village of Mogadore, on the Akron-Mogadore Road and is served by the Akroh, Canton & Youngstown Railroad. (Fig. 1.)

Geology

The shale mined at Mogadore belongs to the Pottsville formation, the lowest of four formations in the Pennsylvanian system. It is of special importance to the ceramic industry as it contains not only several beds of valuable clay and shale but also the necessary fuel for their burning. It extends over approximately 24 counties of the State, reaching from the most southerly point northeastward toward Lake Erie, just east of Cleveland. In some counties, however, the clays are of little value. The formation ranges from 175 to 400 feet in thickness, but averages about 255 feet.

The Pottsville formation itself is composed of shales and sandstone, interbedded with clays, coals, iron ores, and limestone. The members vary greatly in character and thickness from place to place. Those mined at Mogadore are termed the Massillon and the Anthony shales. These are of a siliceous nature and generally plastic in character. The color ranges from light to dark gray.

Opposite ends of the pit disclose interesting sections of these shales as shown below:

East end

	Ft.	in.
Overburden	12	0
Brown shale	5	0
Blue shale	3	0
Coal		2
Light-gray shale	5	0
Dark-gray shale	25	0
	50	2

West end

	Ft.	in.
Overburden	14	0
Sandstone	15	0
Coal	1	0
Sandstone	13	0
Coal		3
Light-gray shale	5	0
Dark-gray shale	20	0
	68	3

3/ Lane, Samuel A., Fifty Years and Over in Akron and Summit County: 1891,p.47

Original from THE OHIO STATE UNIVERSITY

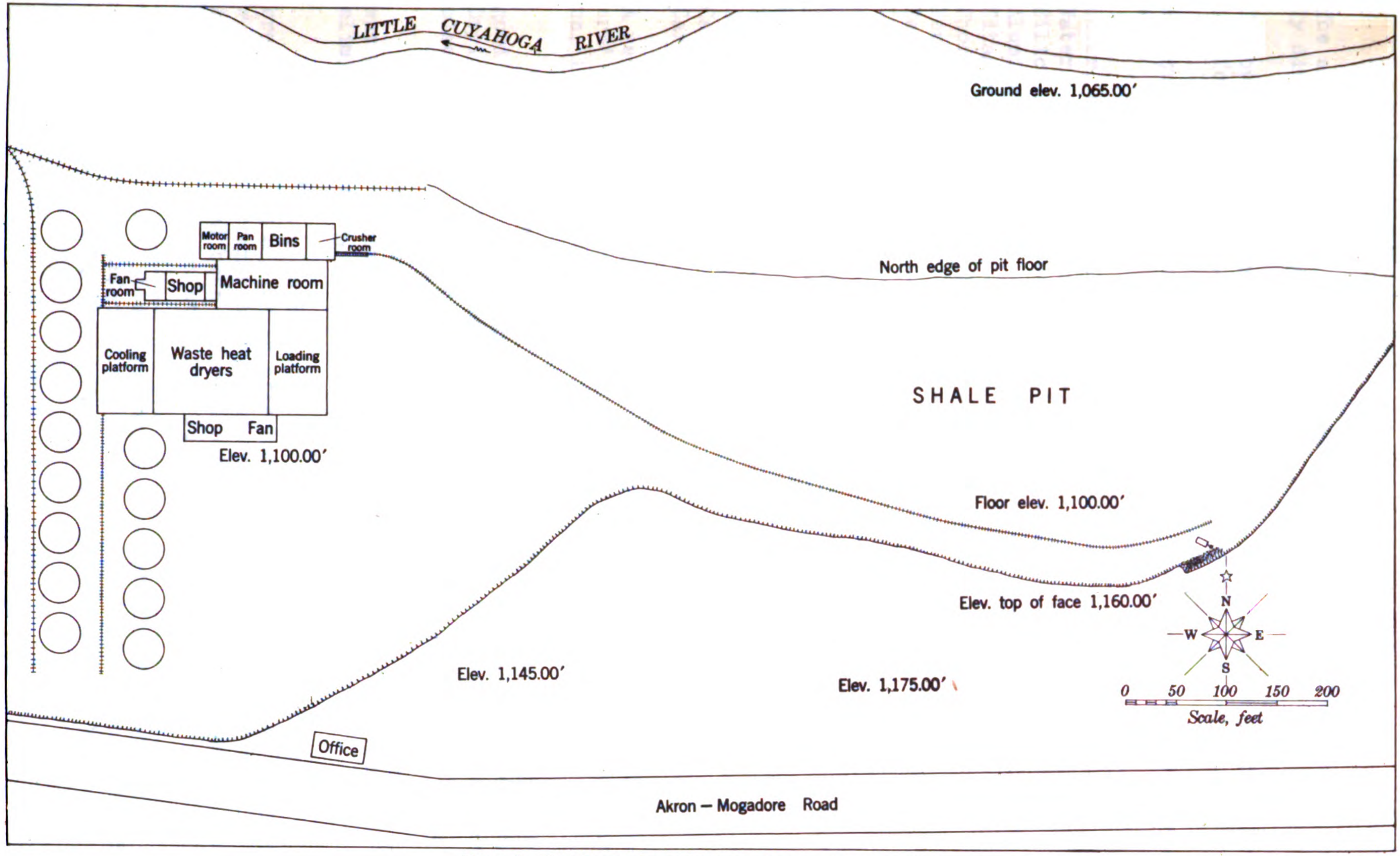

Figure 1.—Plant layout, Camp Brothers Company, Mogadore, Ohio.

Original from THE OHIO STATE UNIVERSITY

The sandstones found in the west end thin out gradually eastward and finally disappear entirely.

The overburden is composed of a yellowish-brown clay of good quality suitable for brick-making. It is used along with the shale.

A chemical analysis of the shale from the Camp Brothers' pit runs as follows:[4]

	Percent
Water, hydroscopic, H_2O	0.78
Water, combined, H_2O	5.27
Silica, SiO_2	60.62
Alumina, Al_2O_3	18.14
Titanic oxide, TiO_2	1.06
Phosporus pentoxide, P_2O_5	.11
Ferric oxide, Fe_2O_3	2.05
Ferrous oxide, FeO	4.10
Lime, CaO	.32
Magnesia, MgO	1.72
Sodium oxide, Na_2O	.10
Potassium oxide, K_2O	2.35
Manganese oxide, MnO	.06
Ferrous sulphide, FeS_2	.38
Sulphur trioxide, SO_3	.25
Carbon dioxide, CO_2	1.85
Carbon, organic, C	1.01

A report on physical tests and properties of the shale from the Camp Brothers' pit, made by the Ohio State University Engineering Experiment Station, is as follows:[5]

> This shale is plastic and works well in the die, yielding a very good column. It is very gritty, large particles being noticeable. Drying can be satisfactorily accomplished if ordinary care is exercised. Firing range, cone 06 to cone 5.
>
> Scumming was produced on all trials above this temperature. It was found that 4 pounds of $BaCO_3$ per ton of clay was necessary to eliminate the scum.
>
> At 2,100° F. a good salt glaze was produced; the color was a brownish green on a pinkish gray background. At 2,050° F. the glaze was a greenish brown mottle, shading into dark brown. On samples to which $BaCO_3$ had been added, the glaze was brown with some white spots showing through at 2,100° F.

---

[4] Courtesy Wilbur Stout, State geologist, Geological Survey of Ohio.

[5] Austin, Chester A., Surface Clays and Shales in Ohio: Ohio State Univ. Eng. Exp. Sta., Bull. 81, 1934, pp. 22, 23, 50, 52, and 53.

At the present time this clay is being used for the manufacture of common brick. It burns to a good red color at cone 1 and has a rather stony structure. Other commercial possibilities for this clay are drain tile, face brick, paving brick, and hollow tile.

Firing Behavior
(P.C.E. Cone=14-15)

Cone	Apparent porosity, percent	Volume shrinkage, percent	Calculated linear shrinkage, percent	Absorption, percent	Bulk specific gravity	Apparent specific gravity
06	24.17	11.36	3.6	12.06	2.00	2.64
04	16.81	15.30	4.9	8.04	2.10	2.52
02	15.06	17.15	5.4	7.06	2.14	2.51
1	12.82	19.72	6.2	5.83	2.20	2.52
3	10.19	21.91	6.8	4.49	2.26	2.52
5	7.62	23.00	7.2	3.29	2.31	2.50
7	9.01	18.85	5.9	4.14	2.18	2.39

Properties of the clay in the plastic and dry states

Slaking time (minutes)	11.10
Water of plasticity (percent)	19.43
Shrinkage water (percent)	5.57
Pore water (percent)	13.86
Dry volume shrinkage (percent)	10.89
Calculated dry linear shrinkage (percent)	3.50
Measured dry linear shrinkage (percent)	3.63
Dry apparent porosity (percent)	25.21
Dry bulk sp. gr.	1.96
Dry apparent sp. gr.	1.92
Dry modulus of rupture (lb. per sq. in.)	273.00
Extrusion strength (inches)	3.59
Dry specific impact strength (cm.-kg per sq. cm.)	1.23
Dry modulus of elasticity (million lb. per sq. in.)	1.393

Screen Analysis

Screen size	14	20	28	38	48	65	100	150	200	Pass 200
Percent	1.67	7.08	12.82	13.89	9.63	9.56	10.51	6.58	6.27	22.49
Cumulative ..	1.67	8.75	21.57	34.96	44.59	54.15	64.66	71.24	77.51	100.00

Original from THE OHIO STATE UNIVERSITY

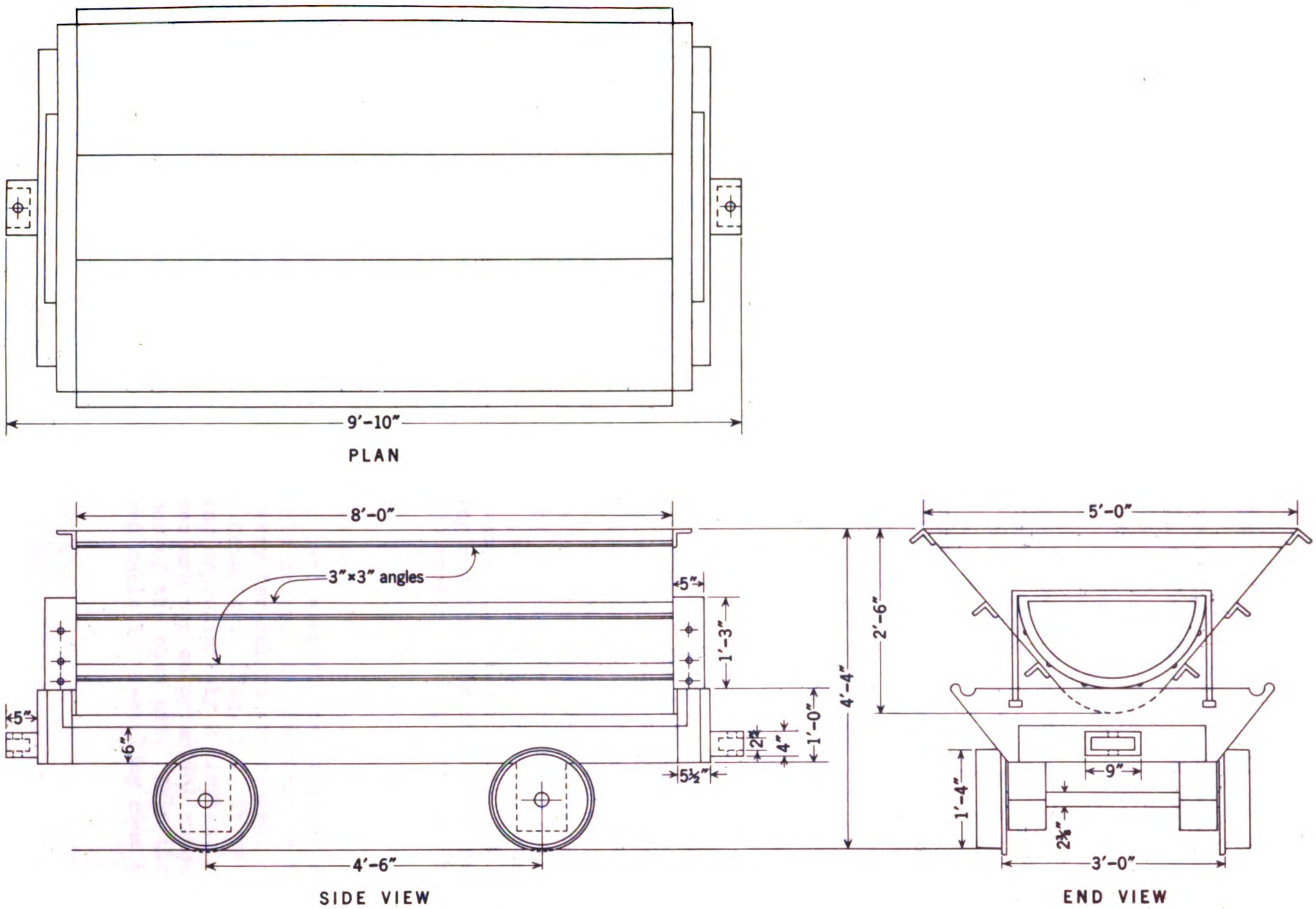

Figure 2.—1¾-cu. yd. capacity side-dump pit car.

Mining Methods

The overburden is a good-quality clay suitable for brick making and therefore is not discarded. It is left in place and shot down with the shale so that a fairly uniform mix results.

Drilling

The shale is drilled with a portable churn-drilling rig. Power is supplied by a 1-cylinder, 5-hp., gasoline motor. Usually a 6-inch hole is drilled through the overburden. This is cased, and a 4-inch hole is then drilled in the shale to the desired depth. The holes are generally drilled about 20 feet from the face and 18 feet apart. Usually, only three holes are drilled and shot. This is done to keep the broken shale as clean and dry as possible for crushing and grinding. Two men operate the drill rig and drill approximately 50 feet in an 8-hour day. These men are drawn from the plant personnel when drilling begins. The motor consumes about 4 gallons of gasoline per day, or 0.08 gallon per foot drilled; total cost per foot is $0.29.

Blasting

Forty-percent gelatin dynamite, size 1-1/4 by 8 inches, is used for blasting. A pocket is first made in the bottom of the hole with about 10 pounds of dynamite. In this pocket are placed about 50 pounds of dynamite and two no. 6 electric detonators. Clay stemming is added, followed by 100 pounds of dynamite and two more no. 6 detonators. This charge is placed approximately 30 feet from the top of the hole, so that the distance between the two charges will vary, depending upon the depth of the hole. Clay stemming is added to fill the hole. The two charges are now connected in series and fired by means of a blasting machine, rack-bar type. The plant superintendent always handles the charging and blasting operations personally. Each hole will produce from 1,700 to 1,900 tons of shale, depending upon the thickness of the deposit.

Loading

The shale is loaded with a 3/4-cubic yard electric caterpillar shovel, driven by a 65-hp., a.c., 3-phase, 60-cycle motor. As the shale is usually broken up into relatively small pieces, very few delays are caused. It is loaded into side dump cars of 1-1/2 tons capacity. (Fig. 2.) Three dippers will ordinarily fill a car, requiring approximately 2 minutes. The loading angle is 120 to 140°. Power lines are run on pyramidal supports, about 10 feet high, that rest on the floor of the open pit. From the last support, a three-conductor, rubber-covered cable 150 feet long runs to the shovel.

Transportation

For transportation, a 3-ton, 4-cylinder, 4 by 6-inch, gasoline locomotive is used to pull a train of two cars. Forty-pound rails, 36-inch gage, are used. Approaching the crusher building, a 7-percent adverse slope, about 300 feet long, is encountered. The cars must be dumped by hand, one at a time, by the locomotive man. It usually takes about 10 minutes for the locomotive to make a round trip to the crusher building, 1,800 feet away. As a rule, the locomotive consumes about 10 gallons of gasoline per day, or approximately 0.04 gallon per ton.

The output of the open pit for a 10-hour working day during 1929 averaged 225 tons of shale. This amount will more than take care of the plant demands.

Drainage

The only water to contend with is the normal rainfall. The pit and plant are located on the side of a slope. The floor of the open pit slopes slightly upward toward the face. With some little ditching, this water drains to the north into the Little Cuyahoga River running across the northern edge of the property approximately 40 feet below the floor of the pit.

Crushing

The shale from the open pit is dumped by hand into a metal-lined wooden hopper of 2-car capacity on the north side of the track in the crusher building. Beneath this hopper, a 42-inch by 10-foot reciprocating plate feeder moves the shale into a 24- by 42-inch single-roll crusher. The feeder is of the swinging-plate type, being suspended from four 48-inch arms. Its speed is 10 strokes per minute, the strokes being 4 inches in length. Depth of material on the feeder plate is 30 inches, and its capacity 90 tons per hour. It is driven by means of a 6-inch by 17-foot rubber belt from a 3-foot-diameter pulley located on the shaft of the crusher roll.

The single roll crusher has a 24-inch-diameter roll fitted with renewable 4-by 4-inch teeth or flutes and mounted on an 8-inch shaft traveling at 40 r.p.m. Its peripheral speed is 245 feet per minute. It is driven by a 40-hp., a.c., 3-phase, 60-cycle, 440-volt motor traveling at 720 r.p.m. through a 14-inch by 14-foot 10-inch rubber belt. The maximum size delivered by the crusher is 6 inches. The life of the renewable flutes is approximately 12 months.

The crushed material falls from the roll crusher upon a 30-inch by 86-foot rubber conveyor belt running over 26-inch-diameter, 32-inch-face pulleys. This belt is inclined upward at 20° from the horizontal for 66 feet and then runs level the remaining 20 feet. It is driven by means of a 20-hp., a.c., 60-cycle, 3-phase motor whose speed is 1,150 r.p.m. through an 8-inch by 7-foot 6-inch rubber belt. Its speed is 270 feet per minute and its capacity is 200 tons per hour. For crushed shale storage there are two rectangular

Original from THE OHIO STATE UNIVERSITY

wooden bins. One, under the end of the belt, has a capacity of 30 tons. The other, beneath the inclined section of the belt, has a capacity of 200 tons. These bins are of such capacity that they provide a large safety factor for the flow of raw shale to the grinding plant, independent of the flow from the open pit. They are located in the crusher building.

Material is drawn from the 30-ton bin by two 26-inch by 8-foot reciprocating-plate feeders. These are of the swinging-plate type, being suspended from four 48-inch arms. Their speeds are 10 strokes per minute, the strokes being 5 inches in length. Depth of material on the feeder plates is 24 inches and their capacities are 40 tons per hour. Each feeder is driven by a 6-inch by 10-foot rubber belt off a countershaft.

The material is drawn off from the larger bin by two 12-inch by 46-foot rubber conveyor belts running over 24-inch-diameter pulleys. Their capacities at 280 feet per minute are 40 tons per hour. Each conveyor is driven by a 6-inch belt from the same counter shaft that drives the previously described plate feeders.

One each of these units feeds directly into a dry pan.

Grinding

For grinding, there are two 10-foot dry pans with a capacity of 18 tons per hour. They consist essentially of a large revolving pan placed between two heavy end frames. The pan is supported on and driven by a forged-steel vertical shaft at 34 r.p.m. The bottom of the pan is composed of bed plates, which form the path of the revolving mullers, 60-inch-diameter, 12-inch-face. Sectional screen plates with 3/16-inch slots are placed outside the path of rotation of the mullers. The friction of the pan on the mullers causes them to rotate on stationary horizontal shafts.

Each dry pan is equipped with a friction-clutch pulley 60 inches in diameter, 14-1/2-inch face, traveling 120 r.p.m., and is driven off a main-line shaft described below.

The crushed shale is fed directly into the open pan. Rotation of the pan draws the shale under the mullers, where it is ground. When ground to sufficient fineness, it passes through the screen plates and out of the pan. The life of the screen plates ranges from 5 to 10 months.

The finely ground shale from the dry pans falls into enclosed vertical belt elevators 16 inches by 54 feet. The size of the buckets is 14 by 6 inches, and they are spaced 10-1/2 inches apart. The capacity of these elevators, running at 220 feet per minute, is 140 tons per hour. There is one elevator for each dry pan. The material is now lifted to the top of the grinding building, where each elevator discharges over two electrically vibrated screens, 3 by 5 feet. These screens are inclined at an angle of 35° with the horizontal. Different-size oblong mesh is employed, depending upon the product to be manufactured in the plant. The size of the openings and the approximate size of the product obtained will run as follows:

Original from THE OHIO STATE UNIVERSITY

Screened Product

Size of opening Inch	Approximate product Mesh
0.1250 by 0.3750	7
.1550 by .5000	5
.1790 by .5000	4-1/2
.1360 by .5000	1/8

The product passing over the screens falls into a 9-by 11-inch wooden chute and is returned by gravity to the dry pans. The material passing through the battery of four screens falls upon a single conveyor belt placed at right angles to the four screens. This is a 22-inch by 60-foot rubber conveyor belt running over 24-inch-diameter pulleys, inclined upward at an angle of 8° from the horizontal. Its capacity, at a speed of 150 feet per minute, is 70 tons per hour. It is driven off a countershaft by an 8-inch by 15-foot belt. The finely ground shale is now discharged into a 30-ton rectangular wooden storage bin located in the machine room.

Beneath the finished storage bin are two circular disk feeders that move the finely ground shale directly into the two pug mills. These feeders are of the concentric type, having a disk 5 feet 6 inches in diameter with a single 30-inch-diameter feed connection and a discharge on one side only. They are driven through a bevel gear on the disk bottom from a counter shaft. Their capacities, at 4-1/2 r.p.m., are 160 tons per hour.

A 150-hp., a.c., 3-phase, 60-cycle, 440-volt motor traveling at 720 r.p.m. drives a main-line shaft through an enclosed chain drive. This motor is located on an elevated platform in the grinding building. This shaft, in turn, supplies motive power through countershafts for the 4 feeders, 2 dry pans, and 2 elevators. The main-line shaft is 4 inches in diameter and travels at 130 r.p.m. A 250-hp., a.c., 3-phase, 60-cycle, 440-volt motor traveling at 600 r.p.m. drives a second main-line shaft, from which the two pug mills, brick machines, and the last conveyor belt above mentioned are driven. This unit is located in the machine room.

An a.c.-d.c. motor-generator set for the electrically vibrated screens is located in a room adjacent to the machine room. A 3-hp., a.c., 3-phase, 60-cycle, 440-volt motor traveling at 860 r.p.m. is direct-connected to a single-phase, d.c., 14.5-cycle, 2-pole, 110-volt, 18.2-ampere generator.

Figure 3 shows a complete flow sheet of the plant.

Power

Electric power is purchased from the Ohio Edison Co. at the rate of $0.021 per kw.-hr. The voltage used throughout the pit and plant is 440.

Original from THE OHIO STATE UNIVERSITY

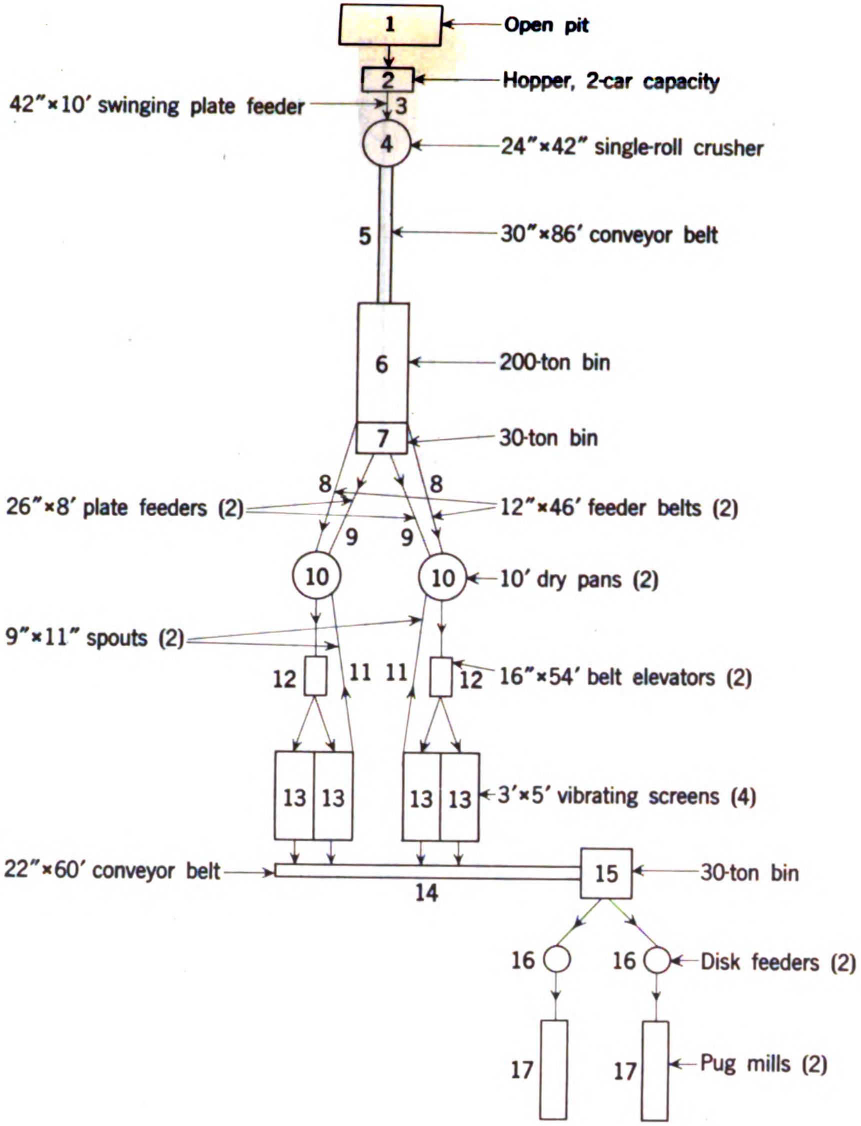

Figure 3.—Flow sheet.

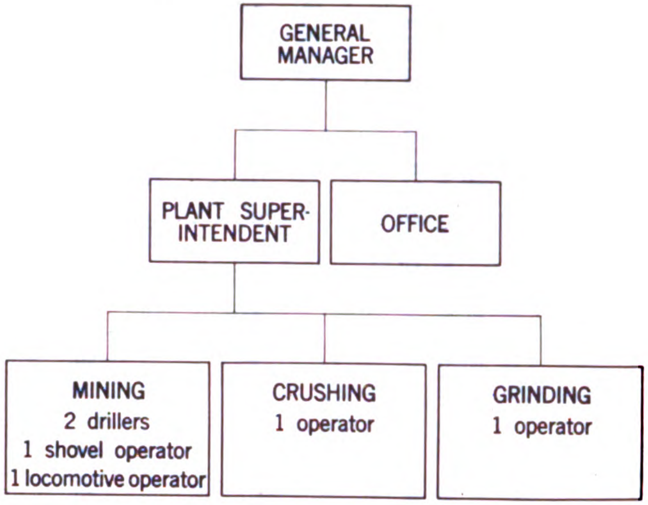

Figure 4.—Organization chart.

Percent Extraction

The overburden and sandstone are used along with the shale, and a 100-percent extraction is obtained from the beds worked. However, there are beds of clay and shale below the pit floor. In places, some of the stoneware clay was removed years ago in an underground mining operation by a previous owner.

Employee Pay System

At present the hourly wage rate is in use, and a 6-hour day is worked. The pit operates approximately 300 days per year.

Labor classification - Rate of pay

Classification	No. of men	Hourly rate	Hours per day
Pit:			
Shovel	1	$0.55	6
Locomotive	1	.45	6
Drilling	1	.45	6
Crushing-Grinding:			
Crusher man	1	.45	6
Grinding man	1	.45	6

Form of Administrative Organization

Figure 4 is an organization chart showing distribution of authority.

I. - SUMMARY OF COSTS

Name: THE CAMP BROTHERS COMPANY, MOGADORE, OHIO Period covered: 1929.

Total material loaded during period: SHALE, 68,423 TONS (2,000 LB.).

Operating costs per dry ton shale mined

	Labor	Supervision	Air-drill steel	Power cost	Fuel cost	Explosives cost	Other supplies	Total
Mining(per ton):								
Drilling	$0.0055	---	$0.0007	---	$0.0026	---	---	$0.0088
Blasting	.0004	---	---	---	---	$0.0136	---	.0140
Loading	.0314	---	---	$0.0105	---	---	$0.0091	.0510
Transportation	.0279	---	---	---	.0066	---	.0039	.0384
Miscellaneous.	.0077	$0.0055	---	---	---	---	.0049	.0181
Crushing	.0270	---	---	.0175	---	---	.0044	.0489
Grinding	.0117	---	---	.0632	---	---	.0044	.0793
Screening	.0032	---	---	.0014	---	---	.0014	.0060
Elevating	.0032	---	---	.0102	---	---	.0013	.0147
Conveying	.0032	---	---	.0130	---	---	.0014	.0176
Misc. plant ..	---	.0085	---	---	---	---	---	.0085
Total	.1212	.0140	.0007	.1158	.0092	.0136	.0308	.3053

Digitized by Google Original from THE OHIO STATE UNIVERSITY

II.- SUMMARY OF COSTS IN UNITS OF LABOR, POWER, AND SUPPLIES

Name: THE CAMP BROTHERS COMPANY, MOGADORE, OHIO. Period Covered: 1929.

Material loaded during period: SHALE, 68,423 TONS. WT. PER CU.YD. LOOSE MEASURE, 2,280 LB.

	Mining	Crushing	Other	Total
A. Labor (man-hours per ton of shale):				
Drilling	0.0082	---	---	0.0082
Blasting	.0003	---	---	.0003
Loading	.0448	---	---	.0448
Haulage	.0433	---	---	.0433
Miscellaneous	---	0.0433	0.0621	.1054
Supervision	.0072	---	.0072	.0144
Total labor	.1048	.0433	.0693	.2174
Average tons per man-shift ..	---	---	---	56.2500
Labor, percent of total cost.	---	---	---	46.2600
B. Power supplies:				
Explosives (lb. per ton)	.1047	---	---	.1047
Total power (kw.-hr. or hp.-hr. per ton-				
1. Drilling - hp.	.1319	---	---	.1319
2. Shovels -- kw.-hr.	.5000	---	---	.5000
3. Locomotives hp.	.8700	---	---	.8700
4. Pumping -- kw.-hr.	---	---	---	---
5. Crushing do.	---	.8334	---	.8334
6. Grinding - k do.	---	---	3.0095	3.0095
7. Screening- do.	---	---	.0667	.0667
8. Elevating -- do.	---	---	.4857	.4857
9. Conveying -- do.	---	---	.6190	.6190
Other supplies in percent of total supplies	---	---	---	2.22
Supplies and power cost percent of total cost	---	---	---	55.74

III. - DETAILED AVERAGE SHOVEL COSTS, DIRECT OPERATION

Name: THE CAMP BROTHERS COMPANY, MOGADORE, OHIO Period covered: 1929.

Type of shovel: ELECTRIC - CATERPILLAR. Size of dipper: $\frac{3}{4}$ cu. yd.

Tons of shale loaded: 68,423.

	Amount	Cost per ton
Shovel operation:		
Engineer	$2100.00	$0.0307
Fuel or power	720.00	.0105
Grease and lubricants	15.00	.0002
Other operating supplies	55.00	.0008
Total supplies	790.00	.0115
Shovel repair labor	50.00	.0007
Repair supplies	550.00	.0081
Total repairs	600.00	.0088
Total shovel operation	3490.00	.0510

IV. - DETAILED SUMMARY COSTS - DIRECT OPERATION - SHALE PIT.

Name: THE CAMP BROTHERS COMPANY, MOGADORE, OHIO Period Covered: 1929.

	Amount	Cost per ton
Loading, all shovels	$3,490.00	$0.0510
Drilling:		
Operating labor	371.00	.0055
Air, gas, power	180.00	.0026
Operating supplies	50.00	.0007
Repair labor	---	---
Repair supplies	---	---
Total drilling	601.00	.0088
Blasting:		
Labor	25.00	.0004
Explosives	929.34	.0136
Other supplies	---	---
Total blasting	954.34	.0140
Haulage:		
Locomotive	2532.15	.0370
Cars	20.00	.0003
Track maintenance	75.00	.0011
Dump maintenance	---	---
Total haulage	2627.15	.0384
General charges	1240.00	.0181
Grand total	8912.49	.1303